Introduction to AGWA2

The Automated Geospatial Watershed Assessment Tool

Assessing post-fire effects using a burn severity map

Introduction	In this exercise you will use the Land Cover Burn Severity Tool and group watersheds and to assess potential impacts of a forest fire.
Goal	To become familiar with using group watersheds to identify watersheds impacted by fire and to learn how to use a burn severity map to simulate hydrologic changes due to fire.
Assignment	Run the SWAT model parameterized with pre-fire land cover, then modify the land cover using the Land Cover Burn Severity Tool with a burn severity map to parameterize the model with post-fire land cover.

Background

Wildfires can, and have had, a profound impact on the nature of watershed response to precipitation (DeBano et al. 1998). Increases in peak runoff rate and volume, as well as sediment discharge, typically increase following fires (Robichaud, et al. 2000; Anderson et al. 1976). Mitigating these effects is one of the primary objectives of the Burned Area Emergency Response (BAER) teams. Weather and climatic conditions often force these teams to make rapid post-fire assessments for decision-making on how and where to deploy remediation measures. Building and running distributed hydrological models to predict potential impacts of fire on runoff and erosion can be a time-consuming and tedious task. The USDA-ARS Southwest Watershed Research Center, in cooperation with the U.S. EPA Office of Research and Development, and the University of Arizona have developed the AGWA geographic information system (GIS) based tool to facilitate this process. A GIS provides the framework within which spatially-distributed data are collected and used to prepare model input files and evaluate model results in a spatially explicit context.

The Study Area

The Aspen Fire in June of 2003 burned 84,750 acres on Mount Lemmon. Mount Lemmon is located in the Santa Catalina Mountains and north of Tucson, AZ (Figure 1). The burned area intersects several drainages on the mountain, including Molino Canyon, Sabino Canyon, Ventana Canyon, Romero Canyon, Canyon Del Oro, Peppersauce Wash, Catalina Wash, and Stratton Wash. This exercise will focus on the impacts of the fire on the Sabino Canyon watershed (16,478 ha).

AGWA will be used to apply a burn severity map to the National Land Cover Data 2001 (NLCD 2001) to produce a modified land cover representing the burned condition of the watershed. The original pre-fire NLCD 2001 dataset and the modified post-fire NLCD 2001 dataset will be used to parameterize the Soil and Water Assessment Tool (SWAT; Arnold and Fohrer, 2005; http://swatmodel.tamu.edu/). A

discussion on the selection of parameter values used to parameterize the models for simulating post-fire runoff and sediment transport is presented by Canfield et al. (2005)* and Goodrich et al. (2005)*.

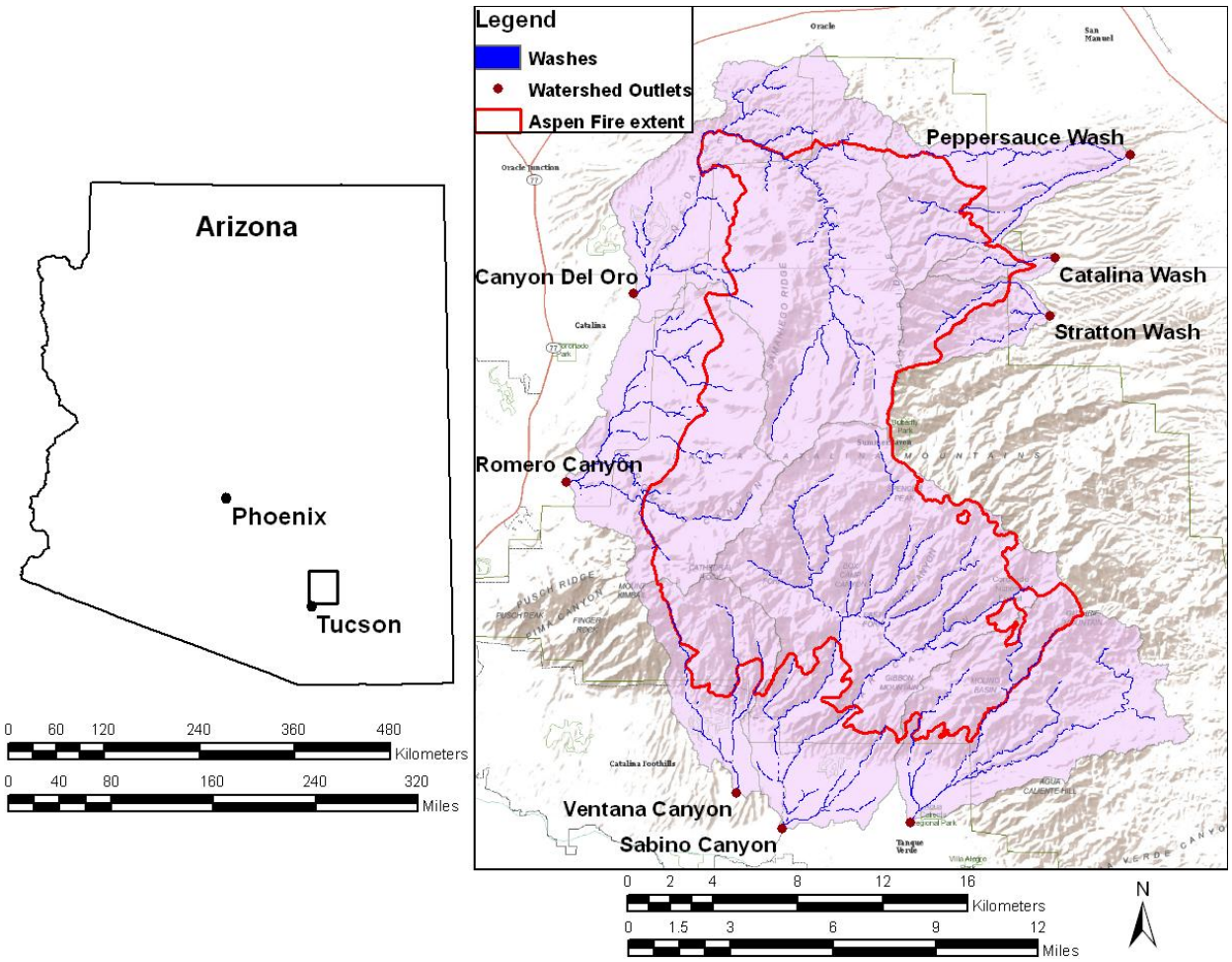


Figure 1. Location Map of the study area, near Tucson, Arizona.

This exercise examines the effects of fire on the hydrology of a particular watershed in the Santa Catalina Mountains. The results disclose immediate changes to the hydrologic regime that are attributable to fire. Changes include the impairment of water resources due to increases in sediment yield and increase of risk due to higher runoff peaks.

Getting Started

Start ArcMap with a new empty map. Save the empty map document as **tutorial_AspenFire**. Turn on the AGWA2 Toolbar if it is not already on. Once the map document is opened and saved, set the HOME and TEMP directories to **C:\AGWA2** and **C:\AGWA2\temp**, respectively.

GIS Data

* Available in PDF format on the AGWA website, http://www.tucson.ars.ag.gov/agwa/.

Add the GIS data to the map by clicking on the *Add Data* button  below the menu bar at the top of the screen. Navigate to the C:\AGWA2\gisdata\tutorials\tutorial_AspenFire\ folder and add the following datasets and layers:

- gsmsoil_az\spatial\gsmsoilmu_a_az.shp
- aspenfire\
    - aspen burn severity.shp
    - demf
    - facg
    - fdg
    - hillshade
    - nlcd2001
    - outlets.shp
    - raingages.shp
    - stream5000

You may want to collapse the legends and rearrange the order of the layers to better see what is going on. Click on the minus box next to the layer name in the Table of Contents to collapse the legend. Click and drag the layers by their names in Table of Contents to rearrange layer order.

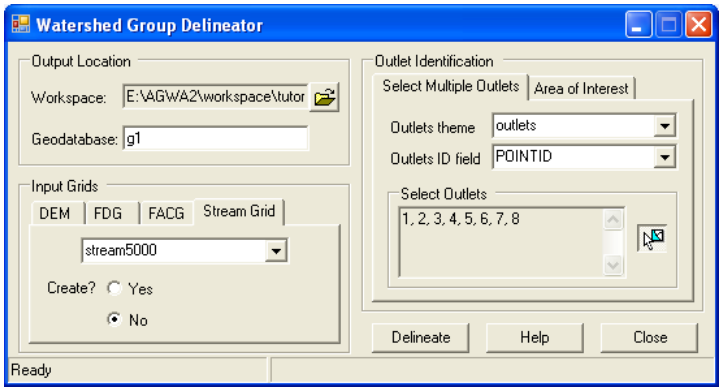
You will also need to add the following files from the C:\AGWA2\datafiles\ folder:

- lc_luts\mrlc2001_lut_fire.dbf – MRLC look-up table for pre-fire and post-fire NLCD land cover
- lc_luts\mrlc2001_severity.dbf – MRLC burn severity change table for NLCD land cover
- precip\catalinas.dbf – unweighted precipitation data for gages around the study area
- wgn\wgn_us83.shp – weather generator stations for SWAT

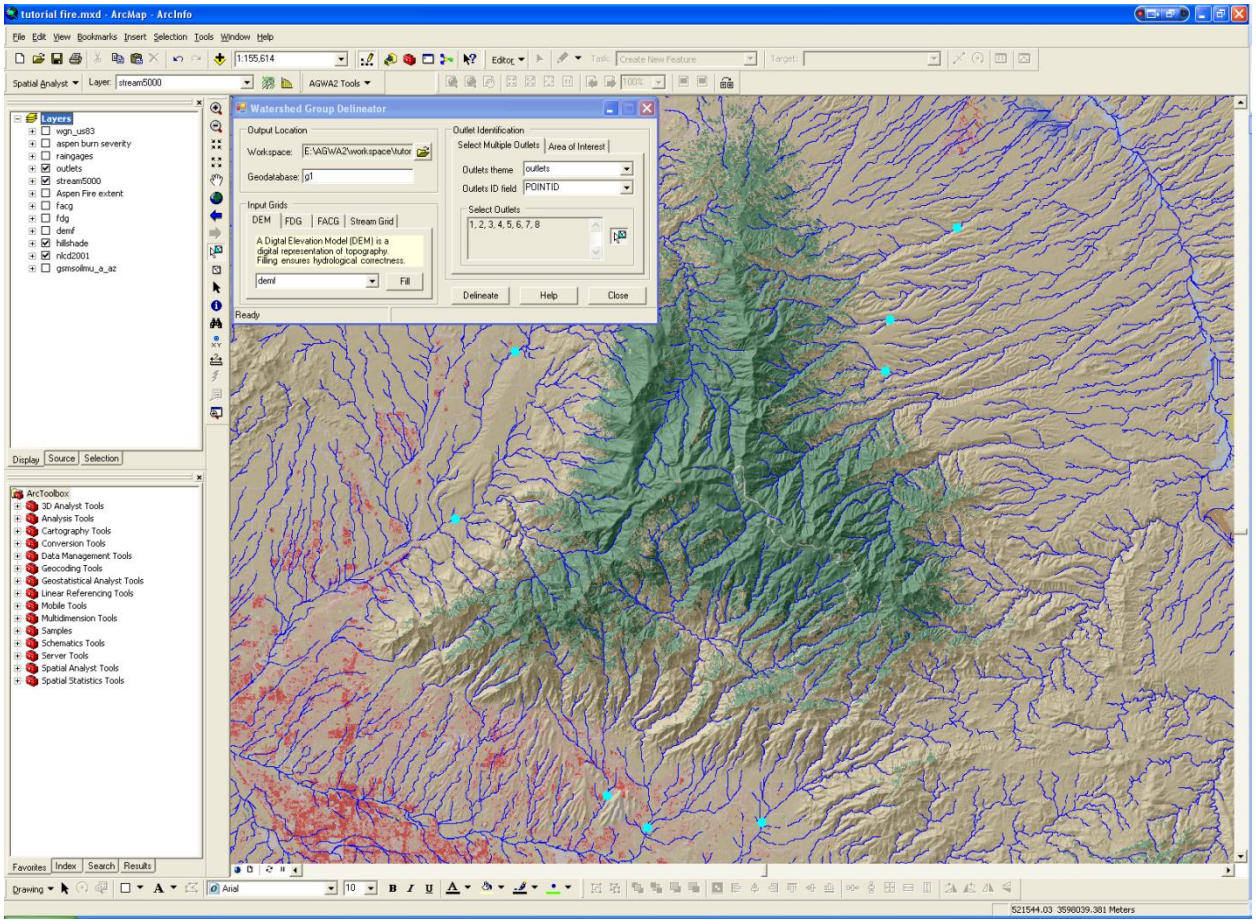
Part 1: Determining Watersheds Affected by the Fire

In Part 1, the drainages intersecting the study area will be delineated to show the watersheds impacted by the fire. The delineated group watersheds will not be used further as the rest of the exercise will focus on a specific watershed and one of its subwatersheds that both intersect the burn area.

1. Perform the watershed delineation by selecting the *Delineate Group Watershed* menu item from the *AGWA2 Tools -> Delineation Options* menu.

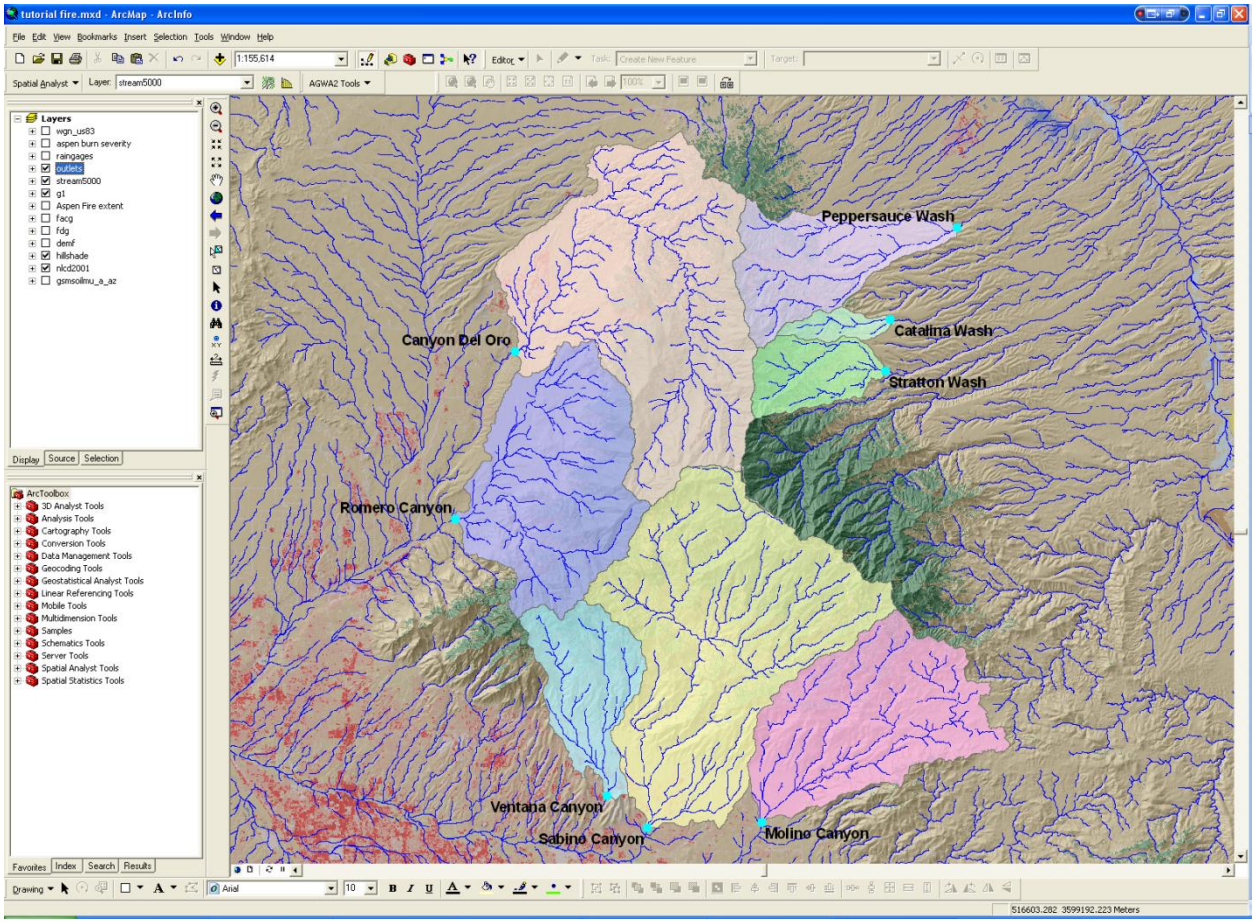


   A. *Output Location* box
      I. *Workspace* textbox: navigate to and select/create **C:\AGWA2\workspace\tutorial_AspenFire**
      II. *Geodatabase* textbox: **g1**
   B. *Input Grids* box
      I. *DEM* tab: select **demf** (do not click Fill)
      II. *FDG* tab: select **fdg** (do not click Create)
      III. *FACG* tab: select **facg** (do not click Create)
      IV. *Stream Grid* tab: select **stream5000** and the ***No*** radiobutton
   C. *Outlet Identification* box
      I. *Select Multiple Outlets* tab
         a. *Outlets theme*: select **outlets**
         b. *Outlets ID field*: select **POINTID**
         c. *Select Outlets* box: Select the *Select Features* tool  and drag a box around the 8 points in the feature class. The textbox should be populated with Outlet numbers 1-8.



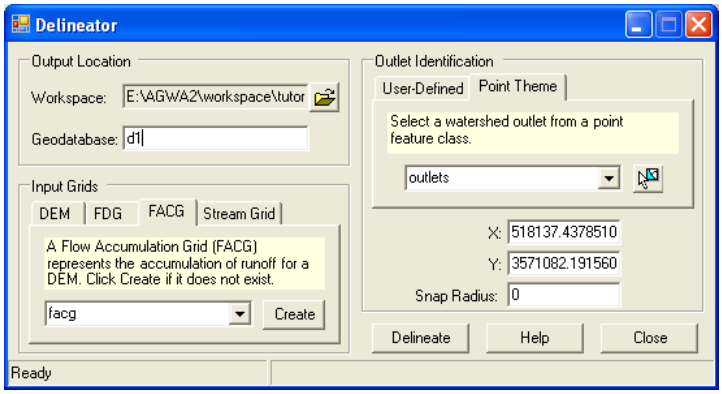
D. Click *Delineate*.

At this point, the group watersheds are delineated and depict the extent of the watersheds affected by the fire. Pre-fire conditions will be simulated in part 2, post-fire land cover will be created in part 3, and then post-fire conditions will be simulated in part 4 so that analysis can be performed in part 5.



Part 2: Modeling Runoff in Study Area Using Existing Pre-Fire Land Cover

1. Perform the watershed delineation by selecting the *Delineate New Watershed* menu item from the *AGWA2 Tools -> Delineation Options* menu.



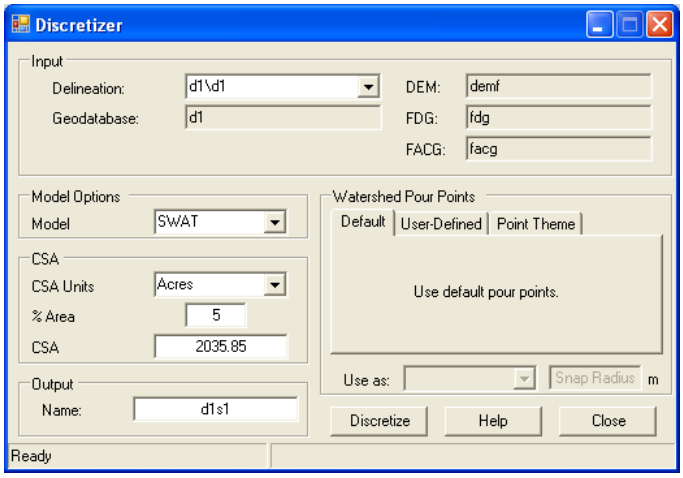
   A. *Output Location* box
      I. *Workspace* textbox: navigate to and select/create **C:\AGWA2\workspace\tutorial_AspenFire**
      II. *Geodatabase* textbox: **d1**
   B. *Input Grids* box
      I. *DEM* tab: select **demf** (do not click Fill)

II. *FDG* tab: select **fdg** (do not click Create)
III. *FACG* tab: select **facg** (do not click Create)

C. *Outlet Identification* box
I. Select the *Point Theme* tab
II. Select the **outlets** layer from the combobox.
III. Click the Select Feature button and draw a rectangle around the **Sabino Canyon** point (see map above).

D. Click *Delineate*.

2. Perform the watershed discretization by selecting the *Discretize Watershed* menu item from the *AGWA2 Tools -> Discretization Options* menu.



A. *Input* box
I. *Delineation*: select **d1\d1**

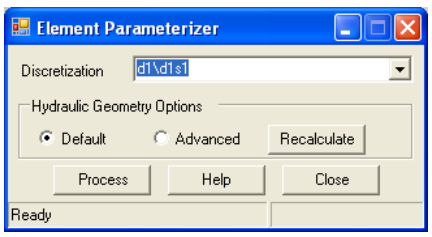
B. *Model Options* box
I. *Model*: select **SWAT**

C. *CSA* box
I. *CSA Units*: select **Acres**
II. *% Area*: Change to 5
III. **CSA**: it should read **2035.85** after changing the *% Area* to 5.

D. *Output* box
I. *Name*: enter **d1s1**

E. Click *Discretize*.

3. Perform the element parameterization of the watershed by selecting the *Element Parameterizer* menu item from the *AGWA2 Tools -> Parameterization Options* menu.



A. *Discretization* combobox: select **d1\d1s1**

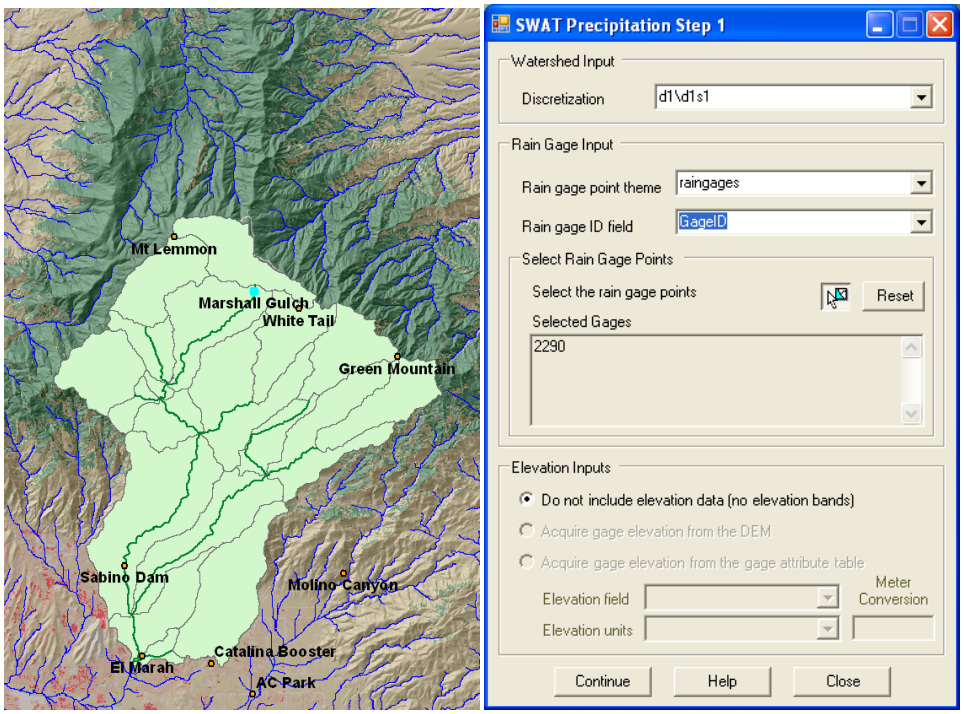
B. *Hydraulic Geometry Options* box: select the ***Default*** radiobutton

C. Click *Process*.

4. Perform the land cover and soils parameterization of the watershed by selecting the *Land Cover and Soils Parameterization* menu item from the *AGWA2 Tools -> Parameterization Options* menu.

A. *Watershed* tab
   I. *Discretization*: select **d1\d1s1**
B. *Land Cover* tab
   I. *Land cover grid*: select **nlcd2001**
   II. Look-up table: select **mrlc2001_lut_fire**
C. *Soils* tab
   I. *Soils layer*: select **gsmsoilmu_a_az**
   II. *Soils database*: navigate to and select **C:\AGWA2\gisdata\tutorials\tutorial_AspenFire\gsmsoil_az\soildb_US_2002.mdb**
D. Click *Continue*.

5. Write the SWAT precipitation file for the watershed by selecting the *Write SWAT Precipitation* menu item from the *AGWA2 Tools -> Precipitation Options* menu.



A. *SWAT Precipitation Step 1* form
   I. *Watershed Input* box:

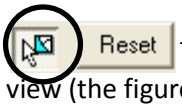
a. Discretization: **d1\d1s1**

II. *Rain Gage Input* box:

a. *Rain gage point theme*: **raingages**

b. *Rain gage ID field*: **GageID**

c. *Select Rain Gage Points* box

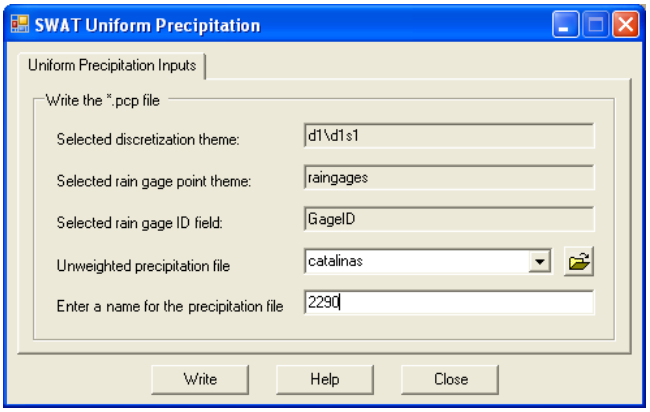
i. Click the *Select Feature* button 

to select the Marshall Gulch raingage in the view (the figure, above left, displays the location of the gage). The id number, 2290, of the selected gage will be displayed in the Selected Gages textbox.

III. *Elevation Inputs* box: *Do not include elevation data (no elevation bands)*

IV. Click *Continue*.

B. *SWAT Uniform Precipitation* form



I. *Write the *.pcp file* box:

a. *Selected discretization theme* (disabled): **d1\d1s1**

b. *Selected rain gage point theme* (disabled): **raingages**

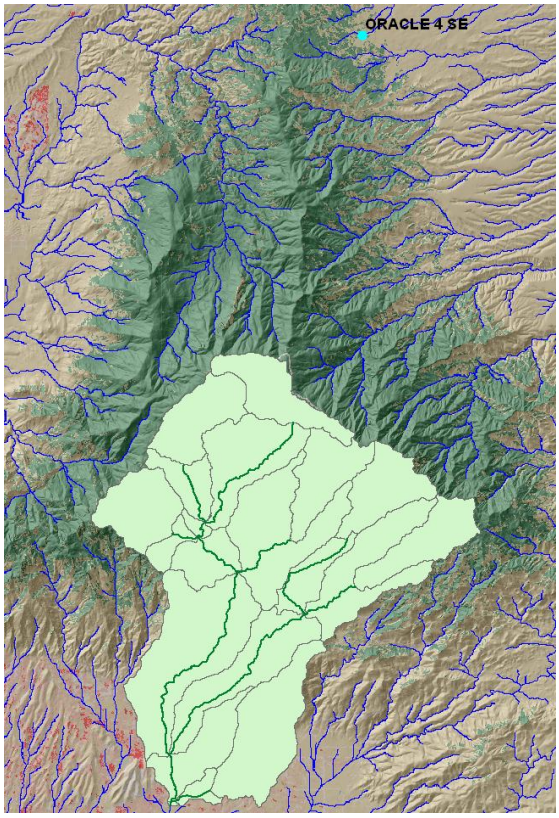
c. *Selected rain gage ID field* (disabled): **GageID**

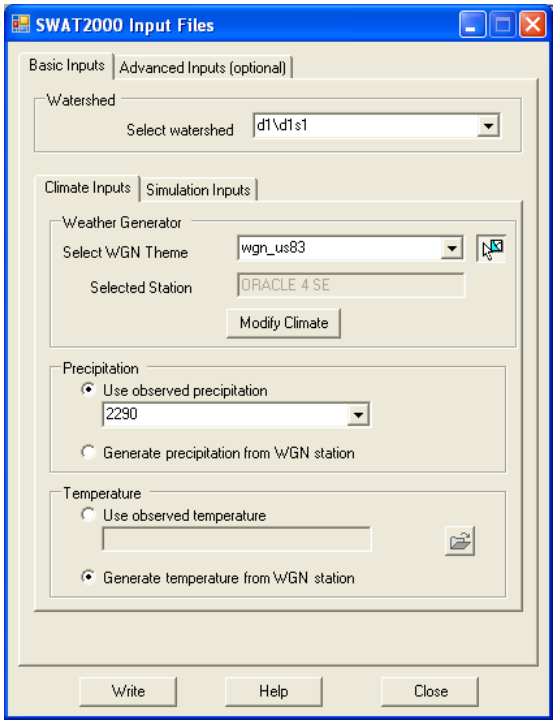
d. *Unweighted precipitation file*: **catalinas**

e. *Enter a name for the precipitation file*: **2290**

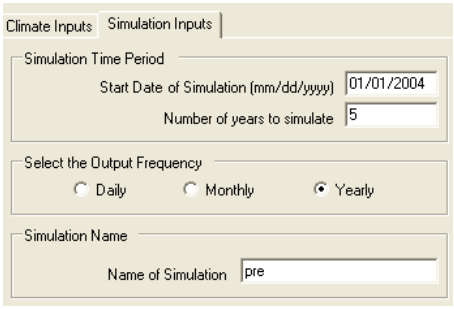
II. Click *Write*.

6. Write the SWAT simulation input files for the watershed by selecting the *Write Input Files* menu item from the *AGWA2 Tools -> Simulation Options -> SWAT2000* menu.





A. *Basic Inputs* tab:
   I. *Watershed* box: **d1\d1s1**
   II. *Climate Inputs* tab:
      a. *Weather Generator* box:
         i. *Select WGN Theme*: **wgn_us83**
         ii. *Selected Station*: **ORACLE 4 SE** (see above left for location)
      b. Precipitation box:
         i. *Use observed precipitation*: **2209**
      c. *Temperature* box:
         i. ***Generate temperature from WGN station***
   III. *Simulation Inputs* tab:



      a. *Simulation Time Period* box:

i. *Start Date of Simulation (mm/dd/yyyy)*: **01/01/2004**

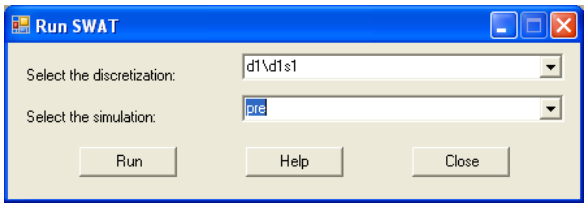
ii. *Number of years to simulate*: **5**

a. *Select the Output Frequency* box: **Yearly**

b. *Simulation Name* box: **pre**

B. Click *Write*.

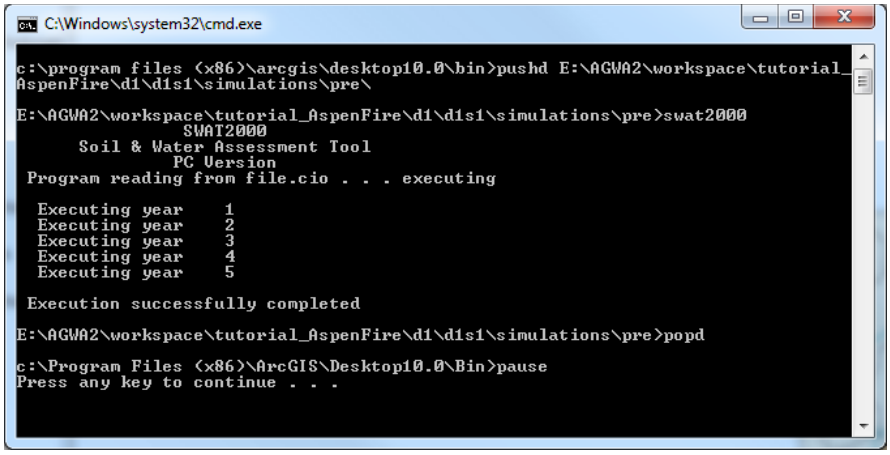
7. Run the SWAT model for the Sabino watershed by selecting the *Run SWAT* menu item from the *AGWA2 Tools -> Simulation Options -> SWAT2000* menu.



A. *Select the discretization*: select **d1\d1s1**

B. *Select the simulation*: select **pre**

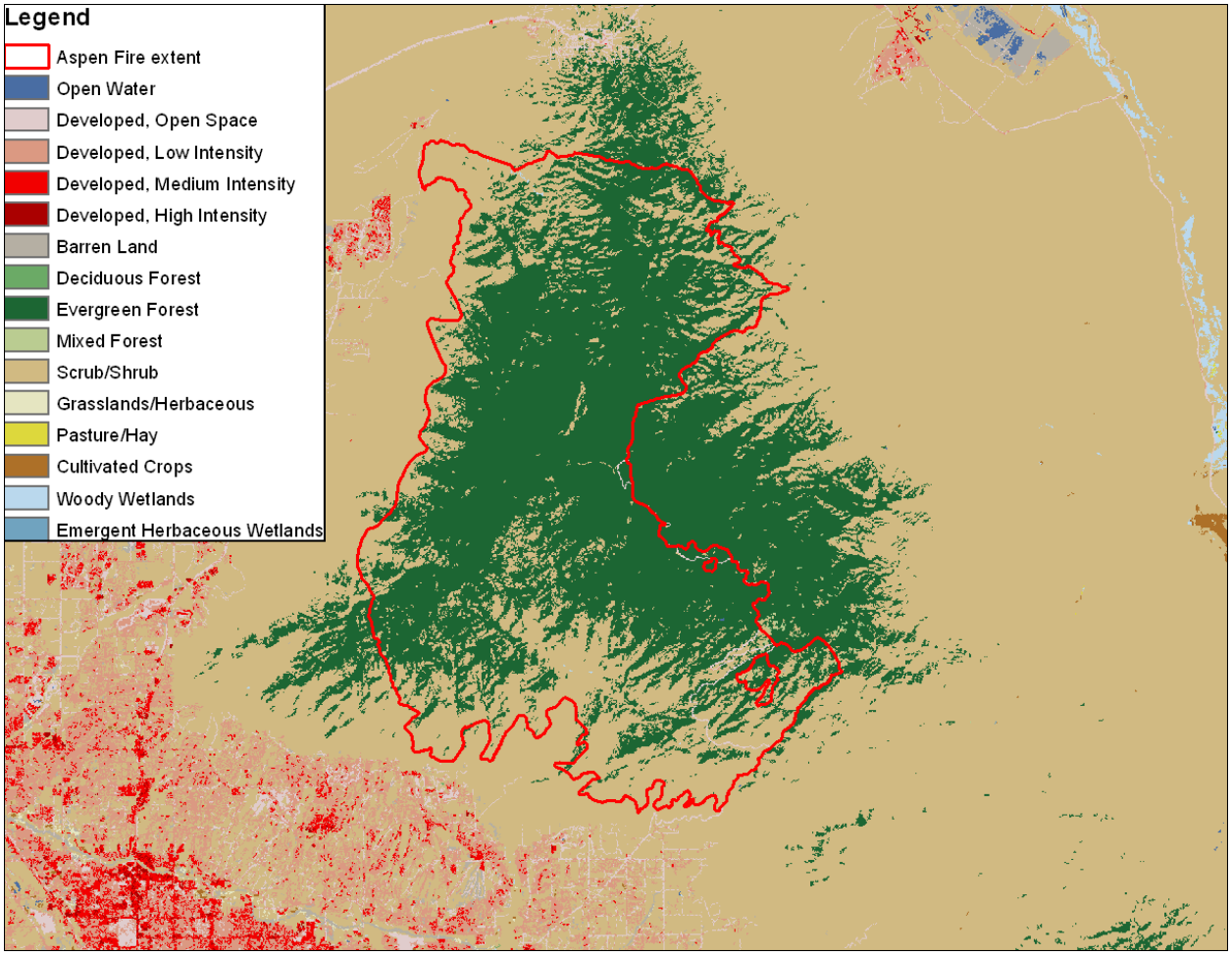
C. Click *Run*. The command window will stay open so that successful completion can be verified. Press any key to continue.



At this point, pre-burn conditions have been simulated; post-burn land cover will be created in part 3 and then simulated in part 4 so that the analysis can be performed in part 5.

Part 3: Create Post-Fire Land Cover

In Part 3, the pre-fire land cover will be used along with a burn severity map representing low, moderate, and high burn intensities (see inset for descriptions) to create a post-fire land cover product.

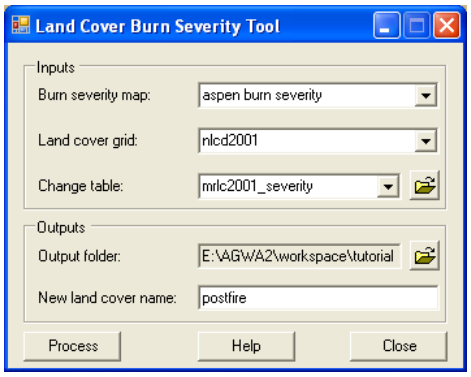


High severity burn - Ground cover is almost completely consumed; the ash layer may be up to two inches deep; tree crowns are completely consumed; few to no leaves or needles remain on trees; tree mortality may be close to 100 percent.

Moderate severity burn - Shrub canopy may be all or partly consumed; shrubs skeletons and root crowns may remain; some identifiable char and litter are beneath a thin ash layer; soil structure is intact; fine and very fine roots remain; scorched brown needles or leaves remain on trees; tree mortality is 40-80 percent.

Low severity burn - Vegetation is lightly scorched; large trees are mostly alive; very small fuels have been consumed.

1. Perform the land cover modification for the post-fire land cover by selecting the Land Cover Modification Tool menu item from the AGWA2 Tools -> Other Options menu.

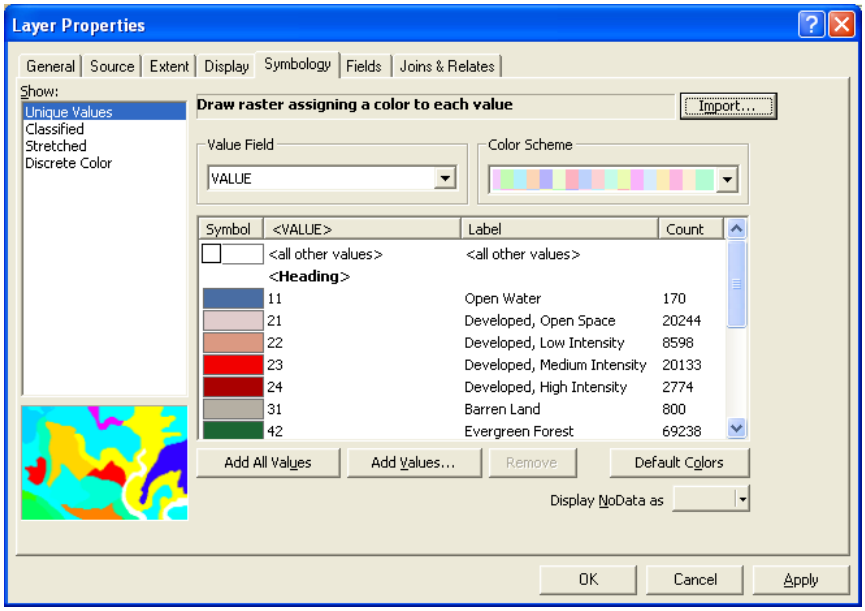


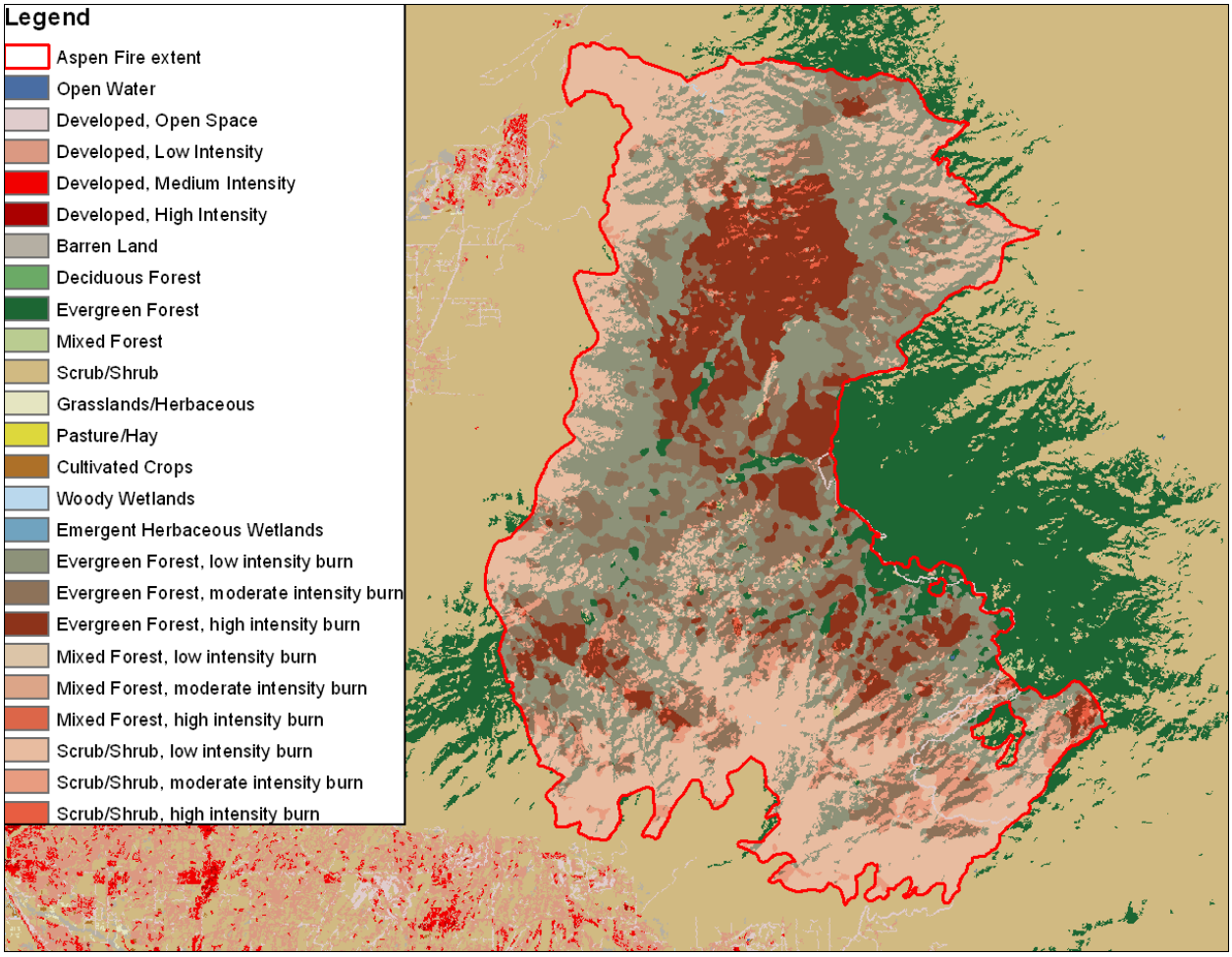
A. *Inputs* box
   I. *Burn severity map*: **aspen burn severity**
   II. *Land cover grid*: **nlcd2001**
   III. *Change table*: **mrlc2001_severity**

B. *Outputs* box
   I. *Output folder*: navigate to and select **C:\AGWA2\workspace\tutorial_AspenFire**
   II. *New land cover name*: **postfire**

C. Click *Process*.

2. At this point, the postfire raster represents the post-fire land cover. For both nlcd2001 and postfire datasets, individually right click on their layer names in the Table of Contents and select ***Properties*** from the context menu that appears. Select the ***Symbology*** tab from the form that opens. In the *Show* box on the left side of the form, select ***Unique Values*** and click the ***Import*** button  on the right. Click the file browser button and navigate to and select **C:\AGWA2\datafiles\renderers\nlcd2001.lyr** for the nlcd2001 dataset and C**:\AGWA2\datafiles\renderers\nlcd2001.lyr** for the post fire dataset.





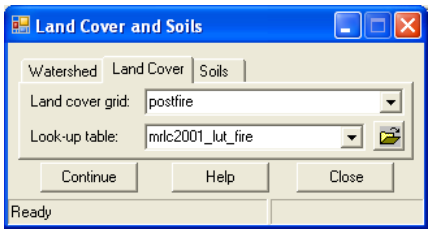
3. To check that the postfire dataset matches the original burn severity map (aspen burn severity.shp), turn all the layers in the Table of Contents off except for **nlcd2001**, **aspen burn severity.shp** and **postfire** by unchecking the checkbox next to the layer names. Toggle these three layers on and off and drag them above or below each other to see how the pre-fire land cover has been modified to match the burn severity map. After you're satisfied, you can rearrange the order of the layers and turn them on/off to your liking.

Part 4: Modeling Runoff in Study Area Using Proposed Post-Development Land Cover

In Part 4, the initial land cover and soils parameterization of the watershed will be overwritten by the post-burn land cover dataset created in part 3. The new parameterization will be used to write a different set of model input files to execute the model.

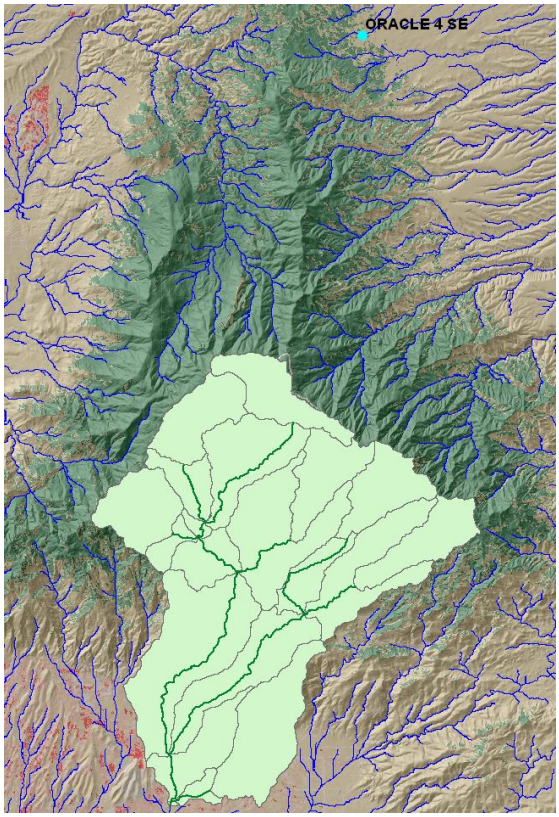
2. Perform the land cover and soils parameterization of the watershed by selecting the *Land Cover and Soils Parameterization* menu item from the *AGWA2 Tools -> Parameterization Options*

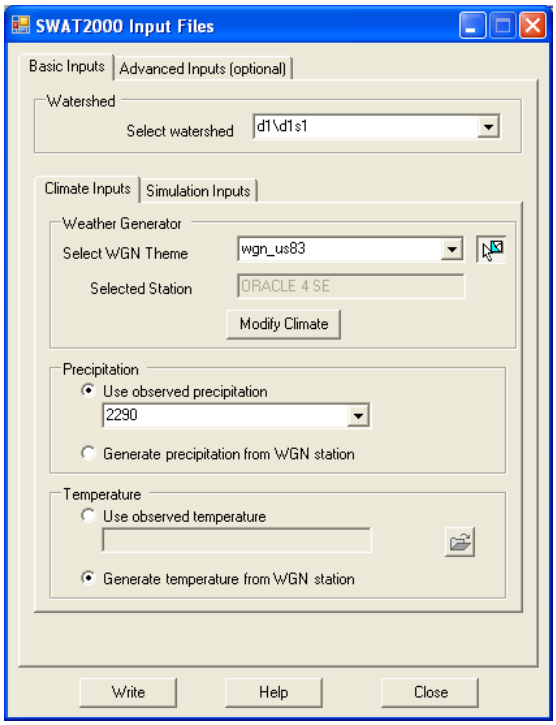
menu.



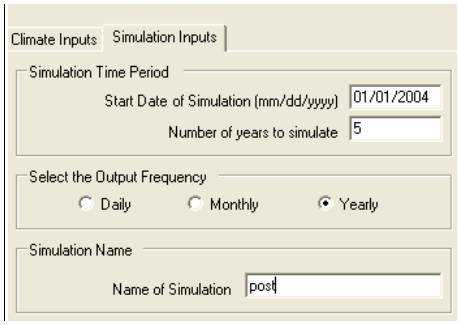
A. *Watershed* tab
    I. *Discretization*: select **d1\d1s1**
B. *Land Cover* tab
    I. *Land cover grid*: select **postfire**
    II. Look-up table: select **mrlc2001_lut_fire**
C. *Soils* tab
    I. *Soils layer*: select **gsmsoilmu_a_az**
    II. *Soils database*: navigate to and select **C:\AGWA2\gisdata\tutorials\tutorial_AspenFire\gsmsoil_az\soildb_US_2002.mdb**
D. Click *Continue*.

3. The same precipitation file used in the pre-fire simulation will be used in the post-fire simulation, so the writing of the SWAT precipitation file performed earlier will be skipped now.
4. Write the SWAT simulation input files for the watershed by selecting the *Write Input Files* menu item from the *AGWA2 Tools -> Simulation Options -> SWAT2000* menu.





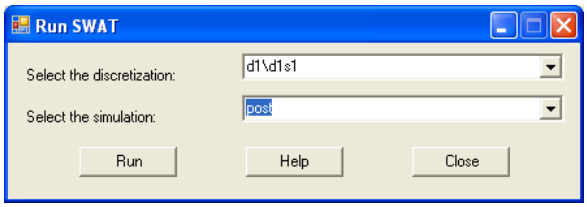
A. *Basic Inputs* tab:
    I. *Watershed* box: **d1\d1s1**
    II. *Climate Inputs* tab:
        a. *Weather Generator* box:
            i. *Select WGN Theme*: **wgn_us83**
            ii. *Selected Station*: **ORACLE 4 SE** (see above left for location)
        b. Precipitation box:
            i. *Use observed precipitation*: **2209**
        c. *Temperature* box:
            i. ***Generate temperature from WGN station***
    III. *Simulation Inputs* tab:



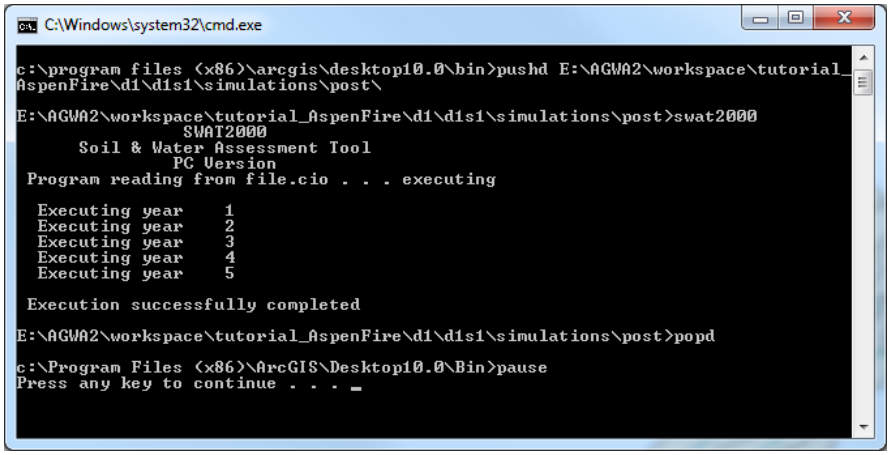
        a. *Simulation Time Period* box:
            i. *Start Date of Simulation (mm/dd/yyyy)*: **01/01/2004**
            ii. *Number of years to simulate*: **5**
        b. *Select the Output Frequency* box: **Yearly**
        c. *Simulation Name* box: **post**

B. Click *Write*.

5. Run the SWAT model for the Sabino watershed by selecting the *Run SWAT* menu item from the *AGWA2 Tools -> Simulation Options -> SWAT2000* menu.



A. *Select the discretization*: select **d1\d1s1**
B. *Select the simulation*: select **post**
C. Click *Run*. The command window will stay open so that successful completion can be verified. Press any key to continue.

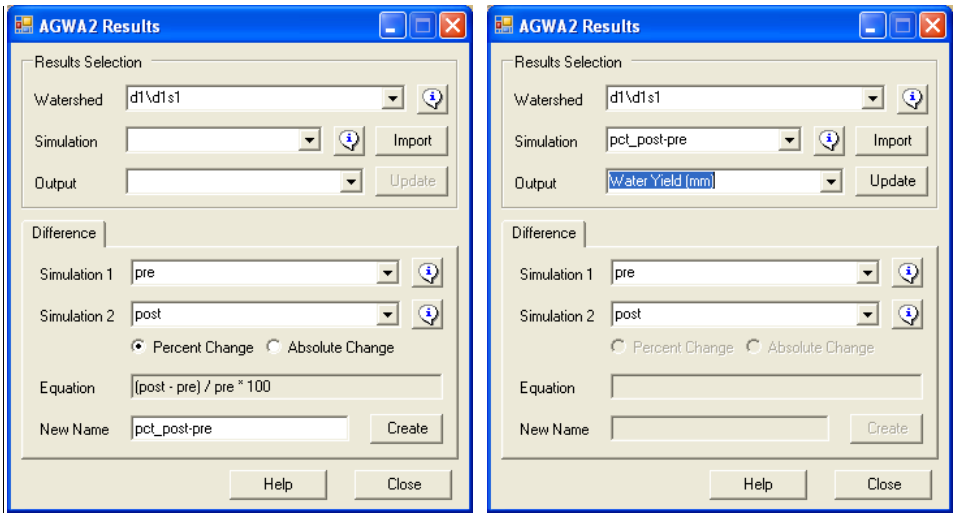


At this point, pre-burn and post-burn conditions have been simulated; in part 5, the pre-burn and post-burn simulations will be directly compared.

Part 5: Comparing Results from Pre-burn and Post-Burn Scenarios

In Part 5, the results from the pre-burn and post-burn simulations will be imported into AGWA. These results will then be differenced to visually see how the fire impacts the hydrology of the watershed.

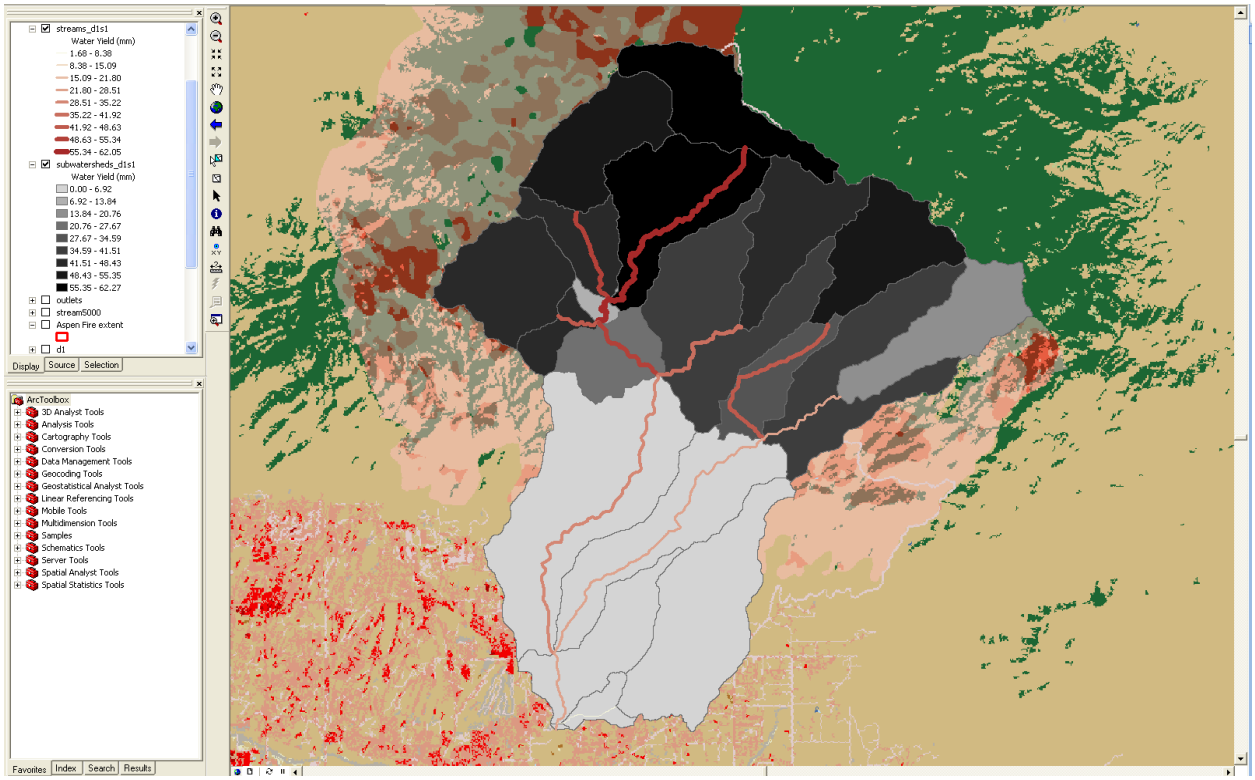
1. Import the results from the two simulations by selecting the *View SWAT Results* menu item from the *AGWA2 Tools -> View Results* menu.



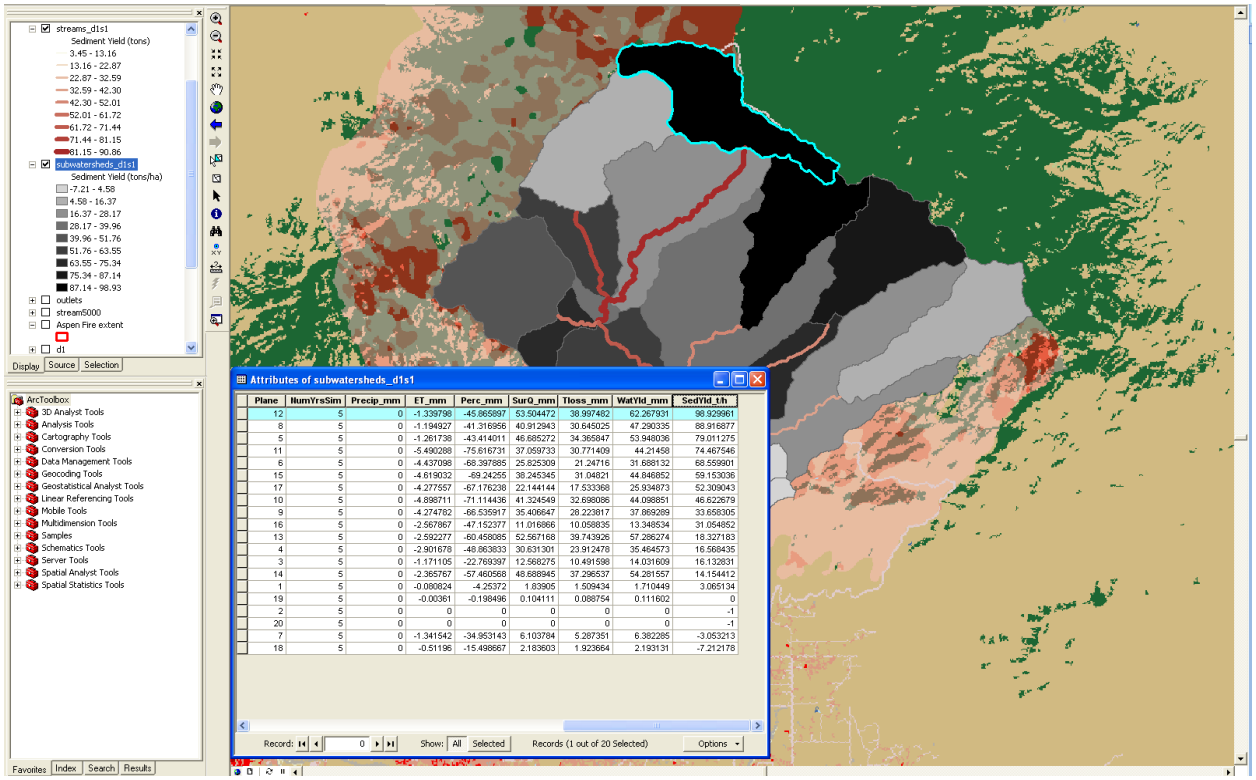
   A. Results Selection box
      I. *Watershed*: select **d1\d1s1**
      II. *Simulation*: click **Import**
         a. **Yes** to importing **post**
         b. **Yes** to importing **pre**
2. Difference the pre-burn and post-burn simulation results.
   A. *Difference* tab
      I. *Simulation1*: select **pre**
      II. *Simulation2*: select **post**

III. Select **Percent Change** radiobutton
IV. *New Name*: enter **pct_post-pre**
V. Click **Create**

3. View the differenced results.
   A. *Results Selection* box
      I. *Watershed*: select **d1\d1s1**
      II. *Simulation*: select **pct_post-pre**
      III. *Output*: select **Water Yield (mm)**
      IV. Click **Update**.



In the next tutorial, we will focus on simulated rehabilitation of the subwatershed with the highest percent change in water and sediment yield (see below).



References

Anderson, H. W., M. D. Hoover, and K. G. Reinhart. 1976. "Forests and water: effects of forest management on floods, sedimentation, and water supply." General Technical Report PSW-18, USDA, Forest Service, Berkeley, CA.

Arnold, J.G., Fohrer, N., 2005. SWAT2000: current capabilities and research opportunities in applied watershed modeling. Hydrological Processes 19(3), 563-572.

Canfield, H.E., D.C. Goodrich, I.S. Burns, 2005. Selection of parameter values to model post-fire runoff and sediment transport at the watershed scale in southwestern forests. In: Proceedings, ASCE Watershed Management Conference, Williamsburg, VA, July 19-22, 2005.

DeBano, L. F., Neary, D.G. and Ffolliott, P.F., 1998. Fire's Effects on Ecosystems. John Wiley and Sons, New York. 338p.

Goodrich, D.C., H.E. Canfield, I.S. Burns, D.J. Semmens, S.N. Miller, M. Hernandez, L.R. Levick, D.P. Guertin, and W.G. Kepner, 2005. Rapid post-fire hydrologic watershed asessment using the AGWA GIS-based hydrologic modeling tool. In: Proceedings, ASCE Watershed Management Conference, Williamsburg, VA, July 19-22, 2005.

Robichaud. P.R. Beyers, J. L., Neary, D.G., 2000 Evaluating the Effectiveness of Postfire Rehabilitation Treatments. United States Forest Service Rocky Mountain Research Station General Technical Report RMRS-GTR-63